

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

09/29/00  
jc511 U.S. PTO  
Applicant: Toshikazu SATO et al.  
Title: GAS RECLAIMING EQUIPMENT  
Appl. No.: Unassigned  
Filing Date: September 29, 2000  
Examiner: Unassigned  
Art Unit: Unassigned

jc511 U.S. PTO  
09/672775  
09/29/00  
jc511 U.S. PTO  
09/672775  
09/29/00

**UTILITY PATENT APPLICATION**  
**TRANSMITTAL**

Commissioner for Patents  
Box PATENT APPLICATION  
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R. § 1.53(b) is the nonprovisional utility patent application of:

Toshikazu SATO  
Toshiaki INOHARA  
Hiroshi MURASE  
Hiromi NAOTSUKA  
Takahiro IMAI

Enclosed are:

- Specification, Claim(s), and Abstract (21 pages).
- Informal drawings (6 sheets, Figures 1-9).
- Unsigned Declaration and Power of Attorney (4 pages).
- Claim for Convention Priority and Priority Document.
- Information Disclosure Statement.
- Form PTO-1449 with copies of 1 listed reference(s).

The filing fee is calculated below:

	Claims as Filed	Included in Basic Fee	Extra Claims	Rate	Fee Totals
Basic Fee				\$690.00	\$690.00
Total Claims:	21	- 20	= 1	x \$18.00	= \$18.00
Independents:	3	- 3	= 0	x \$78.00	= \$0.00
Surcharge Under 37 C.F.R. 1.16(e)				+ \$130.00	= \$130.00
				SUBTOTAL:	= \$838.00
<input type="checkbox"/> Small Entity Fees Apply (subtract 1/2 of above):					= \$0.00
				TOTAL FILING FEE:	= \$838.00

A check in the amount of \$0 to cover the filing fee is enclosed.

The required filing fees are not enclosed but will be submitted in response to the Notice to File Missing Parts of Application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741.

Please direct all correspondence to the undersigned attorney or agent at the address indicated below.

Respectfully submitted,

Date: September 29, 2000

FOLEY & LARDNER  
Washington Harbour  
3000 K Street, N.W., Suite 500  
Washington, D.C. 20007-5109  
Telephone: (202) 672-5489  
Facsimile: (202) 672-5399

By George E. Quillin  
for Johnny A. Kumar  
Attorney for Applicant  
Registration No. 34,649

## GAS RECLAIMING EQUIPMENT

### BACKGROUND

5

#### Field of the Invention

The present invention relates to gas reclaiming equipment used for gas insulated equipment filled with an insulating gas, and more particularly to gas reclaiming equipment adapted for gas-insulated equipment filled with environmentally problematic gasses such as SF<sub>6</sub>/nitrogen insulating gas mixtures.

10

#### Description of the Related Art

Generally, a substation has a circuit breaker and a disconnector to perform a system change and a maintenance check. In particular, large-sized equipment from among the above mentioned equipment use gas insulated equipment filled with SF<sub>6</sub> gas is especially adopted.

Generally, SF<sub>6</sub> gas is highly desirable because of its insulation performance and arc interruption performance. Moreover, since SF<sub>6</sub> gas is a chemically stable and harmless gas, it has been widely adopted as an insulation medium in the above-mentioned equipment. However, SF<sub>6</sub> gas contributes to the greenhouse effect and has a long decomposition life.

Because of environmental protection concerns over a long period of time, the exhaust 20 of SF<sub>6</sub> gas is regulated. Therefore, when performing periodic inspection and parts exchange, the SF<sub>6</sub> gas should be reclaimed so that it does not leak to the outside from the gas insulated equipment.

When reclaiming and storing the SF<sub>6</sub> gas, a large-size tank for storing the SF<sub>6</sub> gas is necessary as the volume of the SF<sub>6</sub> gas gets large. However, it is advantageous to change the 25 gas into a high-pressure state and to reduce the volume of the SF<sub>6</sub> gas. This, however, may generate safety problems.

Accordingly, it has been proposed to use gas reclaiming equipment that converts the SF<sub>6</sub> gas to SF<sub>6</sub> liquid by pressurization and liquefaction of SF<sub>6</sub>. By using such equipment, the tank for reclaiming can be greatly reduced. Furthermore, the safety can be improved.

Figure 1 shows a basic structure of the gas reclaiming equipment. The gas reclaiming equipment is used for reclaiming the gas from gas insulated equipment 1. The gas reclaiming equipment consists of a filter 2, a vacuum/compression pump 3, a gas liquefaction system 6, an SF<sub>6</sub> liquid tank 7, a refrigerator 11, and a cooling pipe 12.

The gas-insulated equipment 1, the filter 2, the vacuum/compression pump 3, the gas liquefaction system 6, and the SF<sub>6</sub> liquid tank 7 are connected to each other through a pipe 13. A valve 14 for controlling the flow rate from the gas liquefaction system 6 or the SF<sub>6</sub> liquid tank 7 is provided. In addition, the filter 2 adsorbs decomposed gas of SF<sub>6</sub>, which occurs due to an arc. The filter also absorbs particulate foreign substances.

SF<sub>6</sub> gas with high-purity and high-dryness is required for the gas insulated equipment 1. Therefore, an adsorbent is used for the purpose of removing moisture or decomposed gas. As the adsorbent, Zeolites with a pore size of approximately 5Å or 10Å are commonly used, since the decomposed gas molecules are larger than a molecule of H<sub>2</sub>O. Even, Zeolites with pore size of 9Å can be used. That is, the size depends on what kind of gas is being reclaimed.

In a conventional gas reclaiming equipment, the SF<sub>6</sub> gas is sent into the gas liquefaction system 6 from the gas insulated equipment 1 through the vacuum/compression pump 3. Additionally, a refrigerant, like chlorofluorocarbon, is sent through the cooling pipe 12 from the refrigerator 11. The SF<sub>6</sub> gas is liquefied in the gas liquefaction system 6 and then the reclaimed SF<sub>6</sub> liquid is stored in liquid tank 7.

If moisture, and various decomposition gases (HF, H<sub>2</sub>O, SO<sub>2</sub> and SOF<sub>2</sub>, SO<sub>2</sub>F<sub>2</sub>), and a related gas molecule (CF<sub>4</sub>), are put in order in terms of the largest to smallest adsorption power, the order could be shown below:

HF, H<sub>2</sub>O, SO<sub>2</sub> and SOF<sub>2</sub>, SO<sub>2</sub>F<sub>2</sub>, CO<sub>2</sub>, SF<sub>6</sub>, CF<sub>4</sub>, N<sub>2</sub>, O<sub>2</sub>

In the above-mentioned list, the reactivity of HF is the highest and HF is chemisorbed.

Its adsorption energy is about 100kcal/mol. It is believed that the rest of the gasses are absorbed by physisorption. The adsorption energy in physisorption is approximately 1-4 kcal/about mol.

5       Compared with chemisorption, physisorption is weaker in terms of adsorption. So, it is believed that gas molecules de-sorb from the adsorbent under the influence of molecular movement in a reduced pressure state. In addition, even if the molecule with weak adsorption is adsorbed by physisorption, when a molecule with strong adsorption arrives, the molecular with strong adsorption adsorbs such that the molecule with the strong adsorption replaces the molecule with weak adsorption.

10       Among these gases, it is hard to de-sorb moisture under reduced pressure. However, under a reduced pressure state for reclaiming SF<sub>6</sub> gas, gases such as SOF<sub>2</sub>, SO<sub>2</sub>F<sub>2</sub>, CO<sub>2</sub>, SF<sub>6</sub>, CF<sub>4</sub>, N<sub>2</sub>, and O<sub>2</sub> de-sorb from the adsorbent. Therefore, gases such as SOF<sub>2</sub>, SO<sub>2</sub>F<sub>2</sub>, CO<sub>2</sub>, SF<sub>6</sub>, CF<sub>4</sub>, N<sub>2</sub>, and O<sub>2</sub> may discharge from the gas insulated equipment 1, and may go into the reclaiming equipment. If so, the filter 2 catches the decomposed gas and any foreign substances, and prevents invasion of the decomposed gas and foreign substances into the gas liquefaction system 6.

15       For when the earth's environment, the quantity of discharged SF<sub>6</sub> gas needs to be reduced further. For that purpose, it is desirable to reduce the quantity of SF<sub>6</sub> gas used.

20       The use of mixed gas, having nitrogen gas as a main component and a little SF<sub>6</sub> gas, is considered to be effective in the curtailment of SF<sub>6</sub> gas. However, the properties of SF<sub>6</sub> gas and nitrogen gas differ remarkably. That is, under the conditions in which SF<sub>6</sub> gas liquefies, nitrogen gas does not liquefy simultaneously. Nitrogen still exists as a gas. Therefore, it is possible to liquefy only SF<sub>6</sub> gas in a mixed gas and to separate SF<sub>6</sub> gas from nitrogen gas.

25       The characteristic values of mixture ratio and liquefaction pressure are shown in Table 1.

Table 1

Mixture ratio	Liquefaction pressure
100 vol % SF <sub>6</sub> gas	2 Mpa
50 vol % SF <sub>6</sub> gas	4 Mpa
10 vol % SF <sub>6</sub> gas	More than 20 Mpa

If the purity of SF<sub>6</sub> gas is high, the pressurization liquefaction of SF<sub>6</sub> gas is easy at room temperature, such as 20 degrees C. However, in order to liquefy SF<sub>6</sub> gas in a mixed gas, high pressure is needed.

5 As shown in Table 1, since a pressure of 20 Mpa or more is needed at room temperature, the liquefaction of SF<sub>6</sub> is very difficult in the case of 10vol% SF<sub>6</sub> gas. Moreover, large-sized refrigeration equipment needs to be used and the liquefaction pressure needs to be lowered. Consequently, the enlargement of equipment has become a problem in reclaiming and recycling mixed gas.

10 Gas reclaiming equipment is disclosed in Japanese Patent Disclosure (Kokai) No.2000-135412. However, there are the following problems with the conventional technology of reclaiming mixed gases containing SF<sub>6</sub> gas. That is, when a mixed gas is incorporated into the gas liquefaction system 6 and the gas liquefaction system 6 liquefies SF<sub>6</sub> gas continuously, the following problem occurs.

15 The concentrated SF<sub>6</sub> gas is liquefied in the gas liquefaction system 6, but the main composition gas, such as nitrogen gas, of the mixed gas continues to accumulate in the gas liquefaction system 6. Therefore, before exceeding the design pressure of the gas liquefaction system 6, this main composition gas needs to be extracted from the gas liquefaction system 6.

20 However, the main composition gas may contain some SF<sub>6</sub> gas, and thus the main composition gas cannot be emitted into the atmosphere. Therefore, in order to prevent the SF<sub>6</sub> gas from remaining in the main composition gas, the reclaiming ratio of SF<sub>6</sub> gas is preferably improved. Moreover, in considering reclaiming the mixed gas, the gas pressure in the gas-

insulated equipment is high early in the reclaiming stage. Therefore, the gas automatically flows into the reclaiming equipment side by only opening a valve. As a result, adjusting the flow rate is easier.

However, in the case when the reclaiming work has been performed, the reclaiming work under reduced pressure becomes necessary. The reclaiming work depends on the capability of the vacuum/pressurization pump. The processing quantity per unit time is reduced under reduced pressure. Therefore, it becomes difficult to secure a sufficient flow rate and the reclaiming efficiency is lowered.

Furthermore, when gas is forcibly extracted with the vacuum/pressurization pump, decomposed gas de-sorbs from the adsorbent in the gas insulated equipment beforehand. Therefore, the decomposed gas will be discharged into the reclaiming equipment side.

If the decomposed gas enters the reclaiming equipment, the life of the reclaiming equipment is adversely affected. Decomposed gas causes, for example, chemical degradation of the pipes in the reclaiming equipment and degradation of the material of the adsorbent.

Therefore, it is desirable that the decomposed gas discharged from the gas insulated equipment be captured with certainty. Moreover, as mentioned above, in the gas insulated equipment, an adsorbent having various Zeolites, for example Zeolites with 5Å or 10Å pores, is usually enclosed.

At this time, the adsorbent includes Zeolites with approximately 10Å pores which adsorbs SF<sub>6</sub> gas for reclaiming. Therefore, if there is a high quantity of the adsorbent, when reclaiming in a reduced pressure condition, the SF<sub>6</sub> gas will de-sorb from the gas insulated equipment side gradually for a long period of time. Therefore, there is a problem in that the reclaiming of SF<sub>6</sub> gas takes a long time. On the other hand, if the adsorbent material has Zeolites with a size if 5Å, it is difficult to adsorb a decomposed gas larger than 5Å in size, and the rate of absorption may decrease.

Therefore, optimization of the combination of Zeolites in the adsorbent in the gas-insulated equipment is desired.

#### SUMMARY OF THE INVENTION.

5 The present invention has been made in view of the above-mentioned circumstances and is intended to solve the above-mentioned problems. In particular, the object of the present invention is to provide a gas reclaiming equipment having a simple and inexpensive structure, and capable of reclaiming SF<sub>6</sub> gas with high efficiency.

10 The present invention provides a gas reclaiming equipment including: a filter for removing a decomposed gas and particulate foreign substances from a mixed gas which is sent from the gas insulated equipment; a pump for sending the mixed gas from the gas insulated equipment to the gas liquefaction system; a gas liquefaction system for reclaiming the mixed gas, wherein the gas liquefaction system liquefies the SF<sub>6</sub> gas of the mixed gas by pressurizing the mixed gas; a storage tank for accumulating a SF<sub>6</sub> liquid obtained by the gas liquefaction system; and a line for returning a gas phase in the gas liquefaction system to a upstream side of the gas liquefaction system.

#### BRIEF DESCRIPTION OF DRAWINGS

20 The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several preferred embodiments of the present invention and, together with the description, serve to explain the principles of the present invention.

Fig. 1 is a diagram showing a basic structure of conventional gas reclaiming equipment.

25 Fig. 2 is a diagram showing gas reclaiming equipment according to a first embodiment of the present invention.

10 Fig. 3 is a diagram showing the gas separation principle according to the first embodiment of the present invention.

15 Fig. 4 is a graph showing the relationship between the equilibrium adsorption and the pressure for a zeolite.

20 Fig. 5 is a detailed diagram showing the gas reclaiming equipment according to the first embodiment of the present invention.

25 Fig. 6 is a graph showing the adsorption characteristics of a Zeolite.

30 Fig. 7 is a diagram showing the gas reclaiming equipment according to a second embodiment of the present invention.

35 Fig. 8 is a diagram showing the gas reclaiming equipment according to another embodiment of the present invention.

40 Fig. 9 is a diagram showing an embodiment of the invention with plural gas separation units.

45 Fig. 10 is a diagram further explaining the gas separation principle.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of gas reclaiming equipment of the present invention are now specifically described in more detail with reference to the accompanying drawings. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or 20 like parts.

25 Fig. 2 is a diagram showing gas reclaiming equipment according to a first embodiment of the present invention. Gas separation equipment 5 is provided between gas insulated equipment 1 and a gas liquefaction system 6. The gas separation equipment 5 separates nitrogen gas from mixed gas, and concentrates the SF<sub>6</sub> gas. Thereafter, only SF<sub>6</sub> gas is sent into the gas liquefaction system 6.

The gas separation equipment 5 includes pressure swing adsorption using an adsorbent with selective adsorption. Moreover, a buffer tank 4, which stores the mixed gas temporarily,

is provided between the gas separation equipment 5 and the gas insulated equipment 1. The buffer tank 4 is operated on the condition that the inside of the buffer tank is pressurized at all times.

The buffer tank 4 and the gas liquefaction system 6 are connected by a reflux-line 19.

5 The reflux-line 19 refluxes the gas in a gas-phase from the gas liquefaction system 6 to the buffer tank 4. The gas-phase contains a very small quantity of SF<sub>6</sub> gas which is equivalent to the vapor pressure of SF<sub>6</sub>. Furthermore, the gas separation equipment 5 is connected to a storage tank 8 for exhaust gas. The storage tank 8 accumulates the nitrogen gas separated through the gas separation equipment 5.

10 The adsorbent 18 having approximately 10Å Zeolites for adsorbing SF<sub>6</sub> gas is enclosed in the storage tank 8 for the exhaust gas. A filter 2 having an adsorbent 2a of the chemisorption type to absorb decomposed gas is interposed between the gas insulated equipment and a pump 3. The adsorbent 2a has a metal hydrate, such as Ca(OH)<sub>2</sub>. The above components are connected with the pipe 13. A valve 14 controls the flow.

15 Operation of the first embodiment will now be described. First, the separation principle of gas in the gas separation equipment 5 is explained by reference to Fig. 2, Fig. 3, and Fig. 4 and Fig. 10.

20 The Zeolites shown in Fig. 3, used as the adsorbent, are enclosed in the gas separation equipment 5. Zeolites are a generic name for crystalline aluminosilicates of alkali. The general formula of Zeolites is shown by MeO• Al<sub>2</sub>O<sub>3</sub>• mSiO<sub>2</sub>• nH<sub>2</sub>O. Moreover, Zeolites have uniform pores on their surface.

25 Since only a molecule smaller than the pore can pass along a narrow pipe of Zeolites, the molecule can be adsorbed inside, as illustrated in Fig. 10. The pores in the Zeolite act like small holes while the molecules of SF<sub>6</sub> and nitrogen gas act like small balls. The “balls” of the same size as the pores get stuck in the pores. This illustrates the outstanding selective adsorption, or molecular sieve effect.

On the one hand, SF<sub>6</sub> gas and nitrogen gas differ from each other in molecular size. The size of the SF<sub>6</sub> molecule varies from DS5.49 - DL6.06, and the size of the nitrogen molecule varies from DS3.1 - DL4.2. The unit of size is Å. DS shows the shorter parameter of the molecule. DL shows the longer parameter of the molecule. Molecular size is described 5 with DS and DL because of its non-spherical shape.

When using Zeolite with a pore-diameter of 5 Å, SF<sub>6</sub> gas is not adsorbed. This is because SF<sub>6</sub> gas is larger than the pore in the Zeolite surface. Nitrogen gas is adsorbed alternatively, and separation of SF<sub>6</sub> gas is provided.

Zeolites have a metal cation in the crystal structure. The metal cation attracts a polar 10 group by static electricity, or a neutral molecule electrically by polarization. Thus, it is believed that the metal cation is widely applicable based on the above mentioned reason.

The gas separation equipment 5 separates the mixed gas with Zeolites by the selective adsorption mentioned above using the pressure swing adsorption method. The basic principle of the pressure swing adsorption method is that the adsorption quantity of the adsorbent is proportional to the gas pressure. Fig. 4 is a graph showing the relationship between the adsorption quantity and pressure.

Fig. 5 is a detailed diagram showing a main part of the gas separation equipment 5. That is, the gas separation equipment 5 has two adsorbent vessels 15a and 15b. An adsorbent 16 with 5 Å Zeolites is contained in the two adsorbent vessels 15a and 15b.

20 The fundamental run pattern of valves B1, B2, B3, B4, B5, B6 and B7 will now be explained. Valves B1 and B4 are open, and the other valves are closed. Moreover, valve B4 is combined with the vacuum/compression pump 3 on the condition that valve B4 is open, and reduced pressure processing is carried out.

First, separation of SF<sub>6</sub> gas will be explained. The mixed gas in the gas insulated 25 equipment flows to a down-stream side with the vacuum/compression pump 3, through the

buffer tank 4. The mixed gas flows into the adsorbent vessel 15a in the gas separation equipment 5.

At this time, the adsorbent vessel 15b is controlled by the vacuum/compression pump 3 under reduced pressure. It is in the early regeneration state and emits the adsorbed nitrogen 5 gas. In the adsorbent vessel 15a, the adsorbent adsorbs only nitrogen gas by the molecular sieve effect. On the one hand, SF<sub>6</sub> gas flows along the upper part, along the flow route, raising its concentration. Finally, gas with high SF<sub>6</sub> gas concentration accumulates on the upper part of the adsorbent vessel 15a.

When the pressure in the adsorbent vessel 15a gets to a predetermined pressure, inflow 10 of mixed gas is stopped, by closing the valve B1, and SF<sub>6</sub> gas concentrated by opening valve B6 is reclaimed. In addition, for better efficiency and stability, values within the limits at 0.2-0.5MPa are usually used.

Subsequently, while valve B6 is closed, the flow route of mixed gas is changed into the adsorbent vessel 15b side by opening valve B3. Thus, SF<sub>6</sub> gas will be separated and concentrated in the adsorbent vessel 15b. First, reduced pressure processing in the adsorbent vessel 15a side is carried out, and the nitrogen gas de-sorbs. While the nitrogen gas is discharged by opening valve B2, the adsorbent 16 will be in the initial state before the adsorbent starts adsorbing.

By repeating the above-mentioned operation, mixed gas is separated into SF<sub>6</sub> gas and 20 nitrogen gas. SF<sub>6</sub> concentrated gas is then sent into the gas liquefaction system 6.

As mentioned above, only nitrogen gas smaller than the pore diameter of the adsorbent 16 can be adsorbed during the adsorption process using high pressure. If the pressure is reduced in the adsorption process, the nitrogen gas currently adsorbed to the adsorbent 16 will de-sorb, and, finally nitrogen gas will be discharged. Furthermore, the adsorbent 16 will be in 25 the initial state simultaneously through this operation. Then, again, when the gas pressure increases, the same quantity of nitrogen gas discharged can be absorbed. Thus, a repeating

operation of absorption and regeneration makes semi-permanent separation of the mixed gas possible.

However, as mentioned above, the initial performance deteriorates gradually due to the strong bonding of moisture and decomposed gas with the adsorbent 16. In such a situation, in order to prevent mixing of the decomposed gas, a designated purity control needs to be carried out. The gas flowed into the reclaiming equipment should be controlled.

As mentioned above, if the initial SF<sub>6</sub> gas concentration is 10 vol % - 50 vol % of the mixed gas, the liquefaction pressure will be set to about 4 MPa at room temperature. Therefore, the existing liquefaction equipment can be used and the risk of liquefaction under high-pressure is also decreased remarkably. Moreover, even though the liquefaction may be performed by using cooling, the increase in size of the equipment is avoidable.

For example, at 20 degrees C, the liquefaction pressure can be reduced up to about 1.3 MPa. Moreover, even if pressure of the gas insulated equipment 1 is reduced in the reclaiming process and the flow rate of mixed gas decreases, mixed gas can be accumulated in the buffer tank 4 temporarily. Therefore, the operation after the gas separation equipment 5 can be stopped, and sufficient flow rate and amount of mixed gas put into the gas separation equipment 5 can be secured by gas accumulation into the buffer tank 4. That is, the appropriate gas flow rate under the reduced pressure condition can be realized, and high reclaiming efficiency can be maintained.

In addition, when the quantity of gas runs short in the buffer tank 4, the reclaiming operation can be stopped and the valves closed. The remaining reclaiming process can then be carried out at the following gas reclaiming operation for another gas insulated equipment. Reduced pressure processing is unnecessary in the buffer tank 4 for the above reason.

On the other hand, the decomposed gas contained in the mixed gas does not de-sorb. Furthermore, in the first embodiment, the adsorbent 2a of the chemisorption type in the filter

2 catches the decomposed gas with certainty. Therefore, the decomposed gas is mixed neither into the gas separation equipment 5 nor the gas liquefaction system 6.

Therefore, the performance degradation related to chemical factors and physical factors does not occur. Thus, the lifetime of the equipment can be prolonged. Moreover, 5 though a very small quantity of SF<sub>6</sub> gas remains in the nitrogen gas separated with the gas separation equipment 5, the adsorbent 18 in the storage tank 8 for exhaust gas adsorbs only SF<sub>6</sub> gas. The same effects can be obtained using a column containing the adsorbent 18 instead of the storage tank 8.

Fig. 6 shows the change of SF<sub>6</sub> gas concentration of a mixed gas with 5% SF<sub>6</sub> gas at a 10 pressure of 0.2MPa when using an adsorbent comprising 10Å Zeolites. Fig. 6 shows that the adsorbent also adsorbs a very small quantity of SF<sub>6</sub> gas with certainty. In addition, SF<sub>6</sub> gas adsorption with an adsorbent 18 having the 10Å Zeolites become saturated. Therefore, after the predetermined quantity processing of SF<sub>6</sub> gas, while SF<sub>6</sub> gas is reclaimed under the reduced pressure, the adsorbent 18 needs to be restored into its initial condition.

In this case, the vacuum/compression pump 3 sends the mixed gas having nitrogen 15 gas, which is the main ingredient, and SF<sub>6</sub> gas into the buffer tank 4, through the piping 13. Moreover, experiments show that the adsorption power of the adsorbent is in inverse proportion to temperature. That is, if temperature is lowered, SF<sub>6</sub> gas adsorbed to the Zeolites increases. On the one hand, SF<sub>6</sub> gas remaining in the gas phase decreases.

20 In other words, if the temperature is raised, the adsorption power will decline, and if the temperature is lowered, the adsorption power increases. That is, when the reproducing of the adsorbent is required in a short time, it is better that the temperature is at 80-100 degrees C.

Since the separation reclaiming is carried out, almost all discharge to the atmosphere 25 of SF<sub>6</sub> gas can be reduced to the appropriate discharge level. Thus, the discharge level shows outstanding environmental harmony.

Moreover, as shown in Fig. 6, according to the experiment, it is ascertained that SF<sub>6</sub> gas can be adsorbed by supplying discharge gas into an adsorbent vessel filled with an adsorbent 18 of 10Å Zeolites. In this case, if the reduced pressure processing is carried out at a gas exit side, SF<sub>6</sub> gas will disperse to the adsorbent in a non-adsorbed portion. Therefore, it is better to perform the reduced pressure processing and to reproduce the adsorbent from the gas entrance side of the column (not shown) provided in the storage tank 8 for exhaust gas. Therefore, it is not necessary to supply a trap at the buffer tank 4. That is, the same effect as the mentioned effect can be attained by flowing the exhaust gas to the adsorbent vessel, filled with the adsorbent 18 having 10Å Zeolites.

As mentioned above, in the first embodiment, the gas separation equipment 5 separates mixed gas into SF<sub>6</sub> gas and nitrogen gas. In this separation operation, preventing SF<sub>6</sub> gas mixing into nitrogen gas as much as possible is desirable. For this reason, when sending SF<sub>6</sub> gas reclaimed in the gas separation equipment 5 to the pump 3, SF<sub>6</sub> gas is also reclaimed by supplying the nitrogen gas together.

In this case, if the nitrogen gas is reclaimed continuously, SF<sub>6</sub> gas and the nitrogen gas continue to accumulate in the gas liquefaction system 6. In other words, although SF<sub>6</sub> gas is liquefied by the gas liquefaction system 6, the nitrogen gas continues to accumulate gradually in the gas state. Therefore, the pressure in the gas liquefaction system 6 may exceed the design pressure.

To prevent this problem, in the first embodiment, nitrogen gas can be returned to the buffer tank 4 from the gas liquefaction system 6 through the reflux-line 19. Thereby, an improvement in safety is obtained. Further, the reclaiming efficiency of SF<sub>6</sub> gas improves sharply by passing this gas again through the gas separation equipment 5 and the gas liquefaction system 6, even though SF<sub>6</sub> gas remains mixed in the nitrogen gas. Therefore, in the reclaiming SF<sub>6</sub> gas, the discharge of SF<sub>6</sub> gas to the atmosphere can be ignored.

In addition, the same effect as mentioned above can be achieved by keeping nitrogen gas in another container temporarily and returning it to the gas separation equipment 5, instead of returning the nitrogen gas through the reflux-line 19 automatically.

A second embodiment is shown in Fig. 7 and Fig. 8. The second embodiment encloses 5 an adsorbent 16 with 5Å and 10Å Zeolites in the buffer tank 4.

In Fig. 7, two buffer tanks 4a and 4b are provided. Furthermore, the adsorbent 16 is enclosed only within the buffer tank 4b. In this embodiment, the pressure of the mixed gas is reduced by controlling the valve 14, and mixed gas is reclaimed. The buffer tanks 4a and 4b, having the adsorbent 16, serve so that the mixed gas may be stored.

According to this embodiment, the adsorbent 16 enclosed in the buffer tank 4b can reliably catch the decomposed gas which passes through the filter 2. Furthermore, the decomposed gas does not mix in the gas separation equipment 5 or the gas liquefaction system 6. Therefore, it is possible to prevent the chemical degradation and physical degradation and to prolong the lifetime of the equipment.

Only when the mixed gas is reclaimed under the reduced pressure, can the mixed gas be stored in the buffer tanks 4a and 4b. Further, the mixed gas can only be passed under a designated pressurization state through the buffer tanks 4a and 4b to an atmospheric pressure.

Therefore, at the beginning of the reclaiming work, with the high gas pressure of the gas-insulated equipment 1, the mixed gas can be reclaimed quickly, and shortening of 20 reclaiming work hours can be attained. Moreover, since an adsorbent 16 with 5Å and 10Å Zeolites is used, the quantity of the adsorption of SF<sub>6</sub> gas can be suppressed. Furthermore, it is possible to adsorb a molecule larger than 5Å quickly from the decomposed gas.

In addition, it is good not to perform the reduced pressure processing in the buffer tanks 4a and 4b, but to perform an operation-stop in the state where a pressure has slightly 25 been applied. That is, it can prevent the decomposed gas from de-sorbing from the adsorbent by applying a pressure within about 0.1-0.2 Mpa, for a while. Furthermore, a film for the gas

separation equipment, as another embodiment, can be used. That is, the thing adapting the difference of the dissolution to a molecular size, a film material for example, can be considered. A film material made from a macromolecule can be used as an example.

Even, as a further embodiment, the gas reclaiming equipment can have plural gas separation units. This embodiment is illustrated in Fig. 9. For example, in the first place, the mixed gas is led to a 1st gas separation unit 21, and the 1st step gas separation unit 21 reclaims concentrated SF<sub>6</sub> gas. Then, gas discharged from the gas reclaiming equipment is led to a 2nd gas separation unit 23. The 2nd step of the gas separation unit 23 again concentrates SF<sub>6</sub> gas contained in a very small quantity.

According to this embodiment, SF<sub>6</sub> gas with high purity and the reduction of the liquefaction pressure of SF<sub>6</sub> gas can be attained by performing plural gas separation processes. Moreover, another embodiment relates to the gas insulated equipment side for making gas reclaiming easy. In this embodiment, an adsorbent with 5Å and 10Å Zeolites is enclosed as a decomposed gas removal material and a desiccant in the gas insulated equipment 1. As the object for the dryness in the gas insulated equipment 1, and the adsorbent for decomposed gas removal, the embodiment is characterized by enclosing an adsorbent mixture with 5Å and 10Å Zeolites.

As for the ratio of the adsorbent with 5Å and 10Å Zeolites, it is desirable that the former becomes more than 80wt% and the latter becomes less than 20wt%.

The quantity of SO<sub>2</sub>F<sub>2</sub> generated is small compared with SOF<sub>2</sub> generated, and it is known that it is ordinarily 1/10 or less. In this embodiment, the adsorbent has two types, approximately 5Å size and 10Å size of pores in the gas-insulated equipment 1, according to the above-mentioned ratio.

The quantity of SF<sub>6</sub> gas adsorption in the gas insulated equipment 1 can be minimized, while maintaining the adsorption performance of the decomposed gas. That is, SF<sub>6</sub> gas does not escape from the gas-insulated equipment 1 for a long period of time, when reduced

pressure reclaiming is performed. Consequently, reclaiming working hours can be shortened and reclaiming efficiency improved.

According to the present invention, the reclaiming performance of SF<sub>6</sub> gas can be improved by setting the reflux-line and returning the gas in the gas phase in the gas liquefaction system to the mixed gas introduction section. Moreover, according to the present invention, SF<sub>6</sub> gas and other insulated gases are efficiently separable with a unique adsorption action of the adsorbent.

Shortening of reclaiming working hours can be attained by this separation, raising SF<sub>6</sub> gas concentration and raising the reclaiming efficiency under reduced pressure. Furthermore, according to the present invention, longevity of the life of the equipment can be enabled by removing decomposed gas discharged from the gas insulated equipment. Furthermore, the optimization of the combination and ratio in the adsorbent in the gas insulated equipment can be attained, and outstanding reclaiming efficiency can be demonstrated.

Japanese priority Application No. PH 11-282045, filed on October 1 and 1999, including the specification, drawings, claims and abstract, is hereby incorporated by reference.

What is claimed is:

1. A gas reclaiming equipment, which is applied to a gas insulated equipment filled with mixed gas including an insulated gas which has SF<sub>6</sub> gas as an ingredient,

5 comprising:

a filter for removing a decomposed gas and a foreign particulate substance from said mixed gas which is sent from said gas insulated equipment;

a gas liquefaction system for reclaiming said mixed gas, wherein said gas liquefaction system liquefies said SF<sub>6</sub> gas of said mixed gas by pressurizing said mixed gas;

10 a pump for sending said mixed gas from said gas insulated equipment to said gas liquefaction system;

15 a storage tank for accumulating a SF<sub>6</sub> liquid obtained with said gas liquefaction system; and

a line for returning a gas in the gas phase in said gas liquefaction system to an upstream side of said gas liquefaction system.

2. The gas reclaiming equipment according to claim 1, wherein said filter has an adsorbent of a chemisorption type which absorbs said decomposed gas.

3. The gas reclaiming equipment according to claim 1, wherein said gas insulated equipment has an adsorbent having Zeolites with approximately 5Å size and 10Å size, and having a ratio of said Zeolites wherein the 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

20 4. A gas reclaiming equipment, which is applied to a gas insulated equipment filled with mixed gas including an insulated gas like SF<sub>6</sub> gas, comprising:

25 a first filter for removing a decomposed gas and a foreign particulate substance from said mixed gas which is sent from said gas insulated equipment;

a gas liquefaction system for reclaiming said mixed gas, wherein said gas liquefaction system liquefies said SF<sub>6</sub> gas of said mixed by pressurizing said mixed gas; a pump for sending said mixed gas from said gas insulated equipment to said gas liquefaction system;

5 a first storage tank for accumulating a SF<sub>6</sub> liquid obtained by said gas liquefaction system;

a gas separation equipment for separating said SF<sub>6</sub> gas from said mixed gas, and sending said SF<sub>6</sub> gas into said gas liquefaction system, said gas separation equipment provided between said gas insulated equipment and said gas liquefaction system; and

10 a buffer tank for storing said mixed gas, said buffer tank provided between said gas insulated equipment and said gas separation equipment.

5. The gas reclaiming equipment according to claim 4, wherein said buffer tank has an adsorbent comprising Zeolites with 5Å size and 10Å size.

6. The gas reclaiming equipment according to claim 4, wherein said buffer tank stores said mixed gas when said mixed gas is reclaimed under reduced pressure.

7. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment includes pressure swing adsorption including an adsorbent with selective adsorption.

8. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment has a second filter with a permeable membrane.

9. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment has plural separating units to separate said SF<sub>6</sub> gas from said mixed gas.

10. The gas reclaiming equipment according to claim 4, further comprising: a second storage tank storing a specified gas separated by said gas separation equipment, said second storage tank including an adsorbent to adsorb said SF<sub>6</sub> gas.

11. The gas reclaiming equipment according to claim 4, wherein said filter has an adsorbent to adsorb said decomposed gas.

12. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment includes an adsorbent having Zeolites with approximately 5Å size and 5 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

13. A method of reclaiming insulating gas from a mixed gas of a gas insulated equipment comprising:

flowing the mixed gas though a filter to remove decomposed gas and foreign 10 particulate substances;

flowing the mixed gas to a gas liquefaction system;

liquefying the insulating gas; and

returning gas in the gas phase from the gas liquefaction system to an upstream side of the gas liquefaction system.

15 14. The method of claim 13, further comprising chemisorbing decomposed gas in said filter.

15. The method of claim 13, further comprising flowing said mixed gas through a gas separation unit.

16. The method of claim 15, wherein said gas separation unit includes an 20 adsorbent having Zeolites with approximately 5Å size and 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

17. The method of claim 15, further comprising flowing mixed gas from said gas separating equipment to a storage tank.

18. The method of claim 17, wherein said storage tank includes an adsorbent to adsorb decomposed gas.

19. The method of claim 17, wherein said storage tank includes an adsorbent to adsorb SF<sub>6</sub> gas.

5 20. The method of claim 13, further comprising flowing the mixed gas through a buffer tank.

21. The method of claim 20, wherein said buffer tank includes an adsorbent having Zeolites with approximately 5Å size and 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

## ABSTRACT OF THE DISCLOSURE

A gas reclaiming equipment capable of separating SF<sub>6</sub> gas from a mixed gas 5 efficiently and shortening reclaiming work under reduced pressure. A gas separation equipment is provided between a gas insulated equipment and a gas liquefaction system. The gas separation equipment separates nitrogen gas from the mixed gas, and concentrates SF<sub>6</sub> gas. Only SF<sub>6</sub> gas is sent into the gas liquefaction system. The gas separation equipment uses pressure swing adsorption using an adsorbent with selective adsorption. Moreover, a buffer 10 tank for storing mixed gas is provided between the gas separation equipment and the gas insulated equipment. The buffer tank and the gas liquefaction system are connected by a reflux-line. The reflux-line refluxes the gas in a gas phase in the gas liquefaction system to the buffer tank. Furthermore, the gas separation equipment is connected to a storage tank. The storage tank accumulates the nitrogen gas separated with the gas separation equipment. The 15 adsorbent to adsorb SF<sub>6</sub> gas is enclosed in the storage tank for exhaust gas. To absorb decomposed gas, the filter has an adsorbent of the chemisorption type. The adsorbent has of a metal hydrate.

Fig. 8

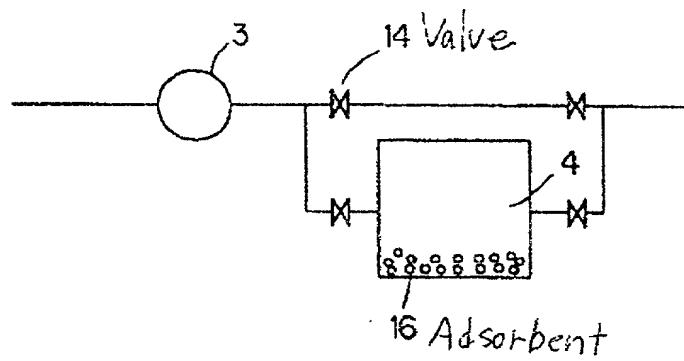


Fig. 1

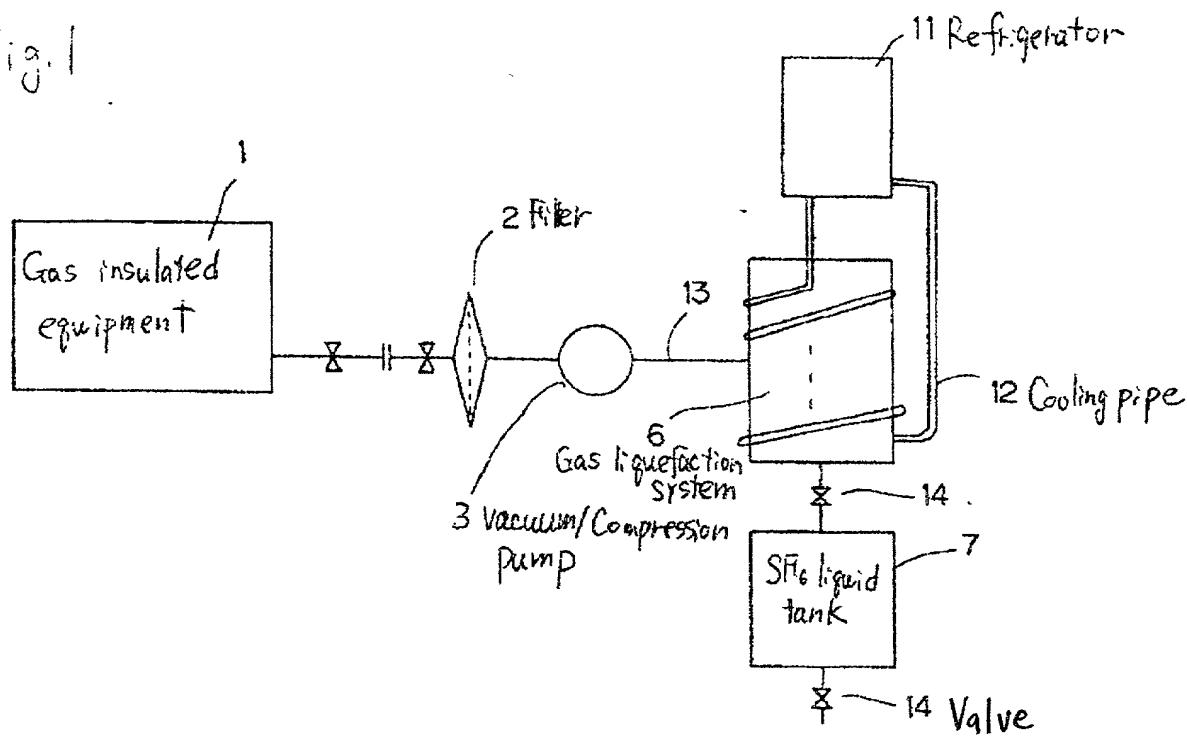


Fig. 2

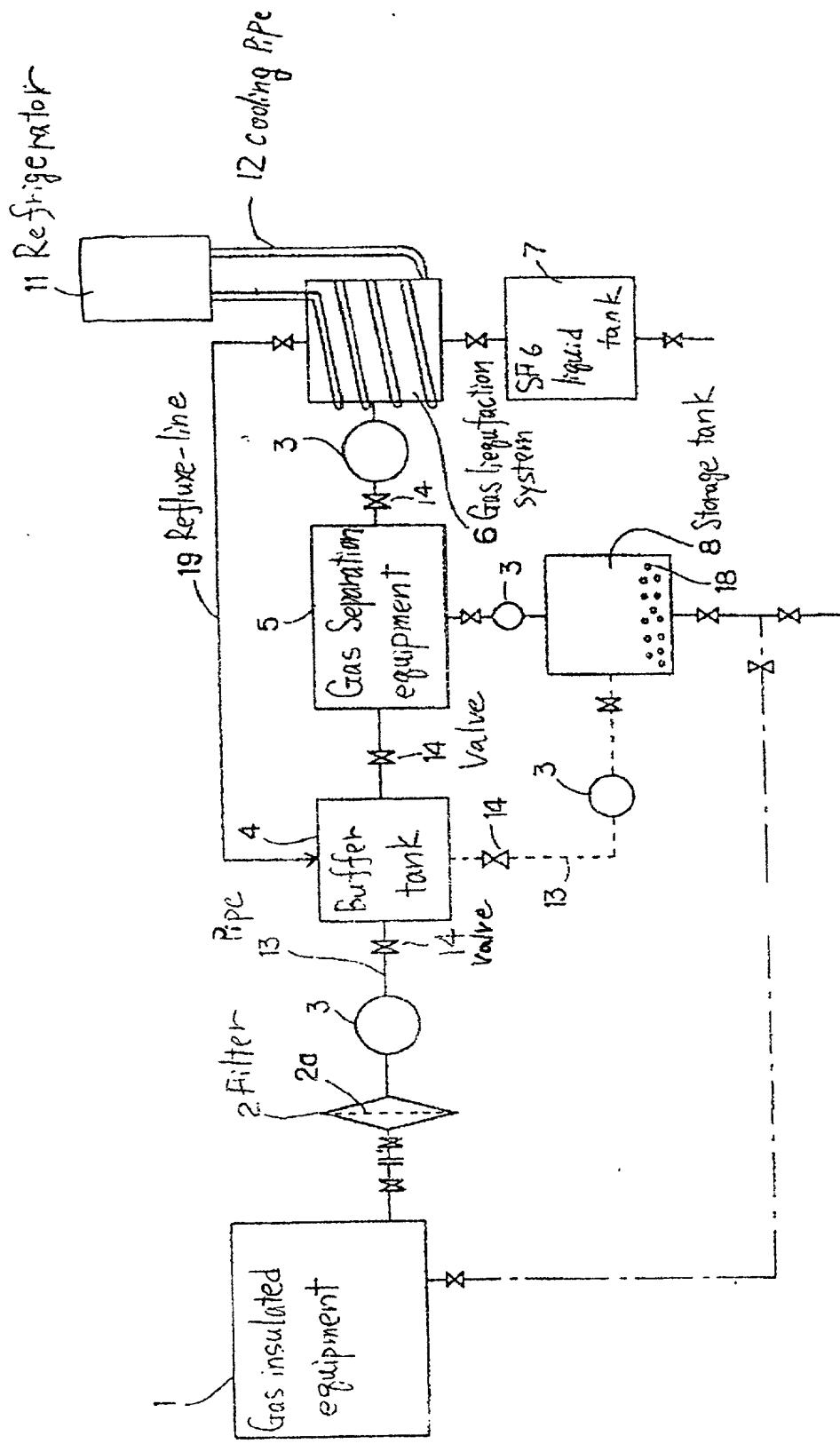


Fig. 3

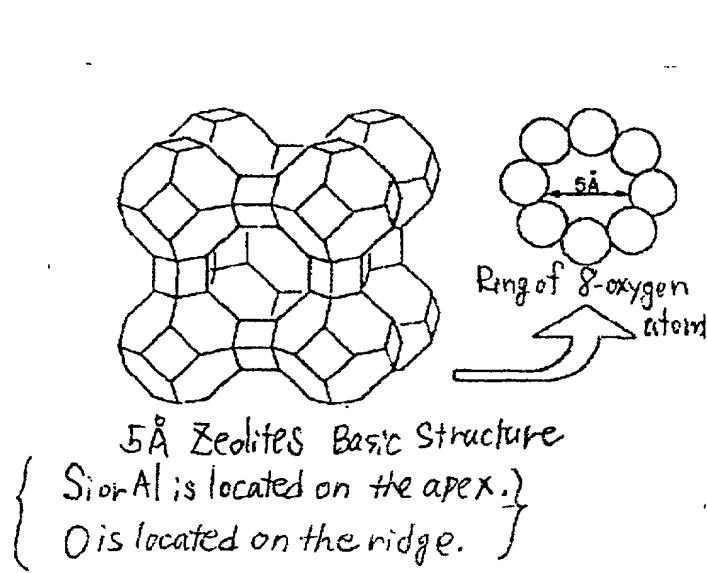


Fig. 10

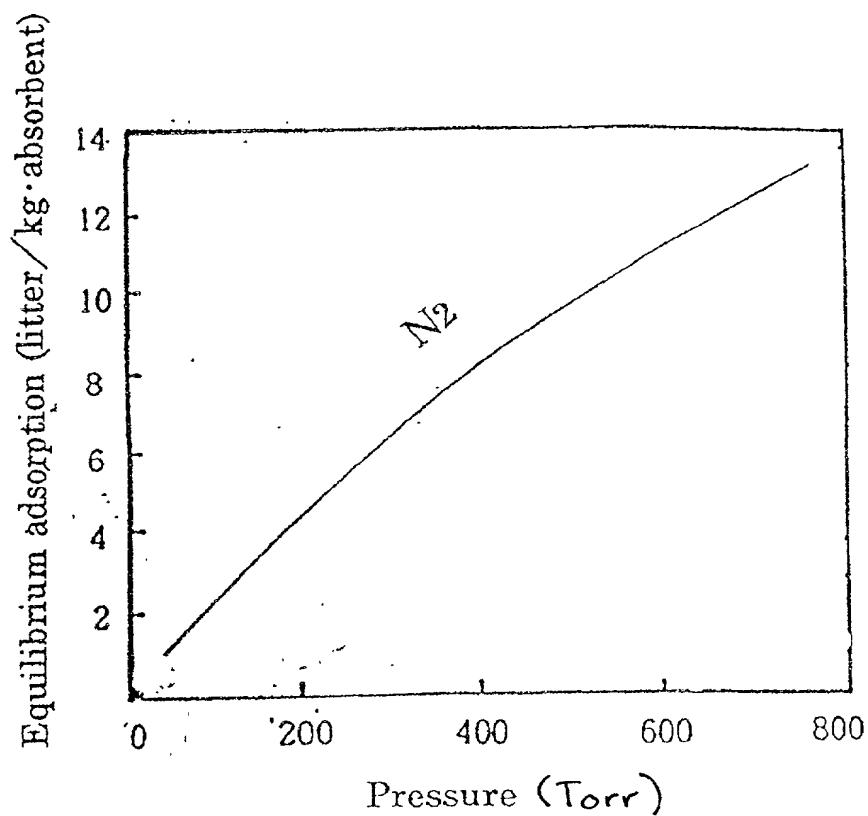
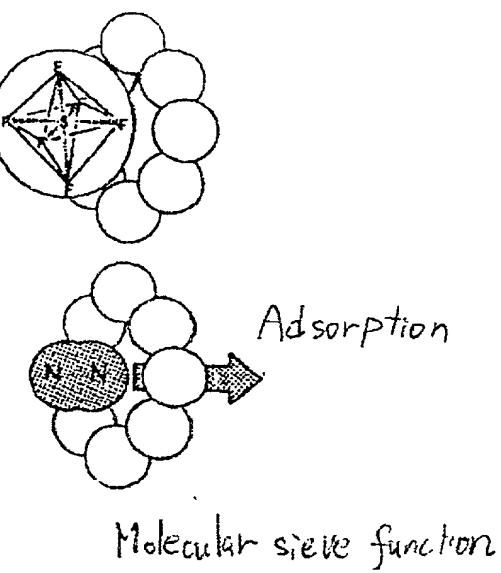


Fig. 4

Equilibrium adsorption vs Pressure (zeolite type 4~5 Å)

Fig. 5

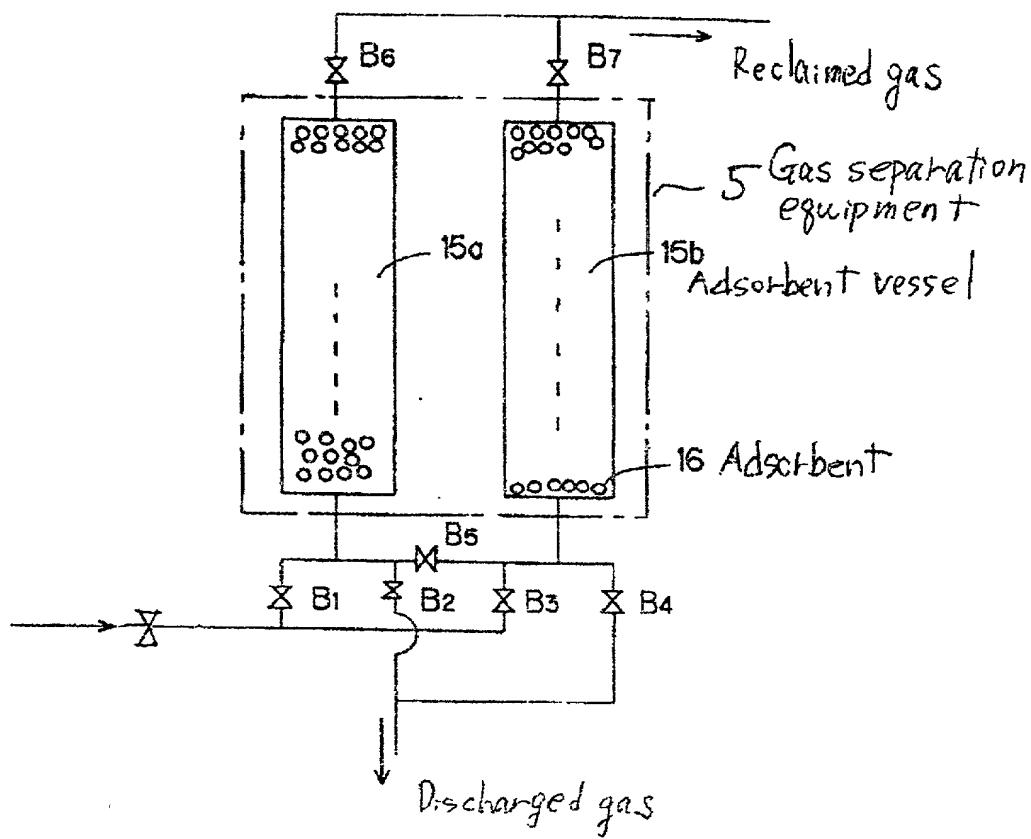


Fig. 6

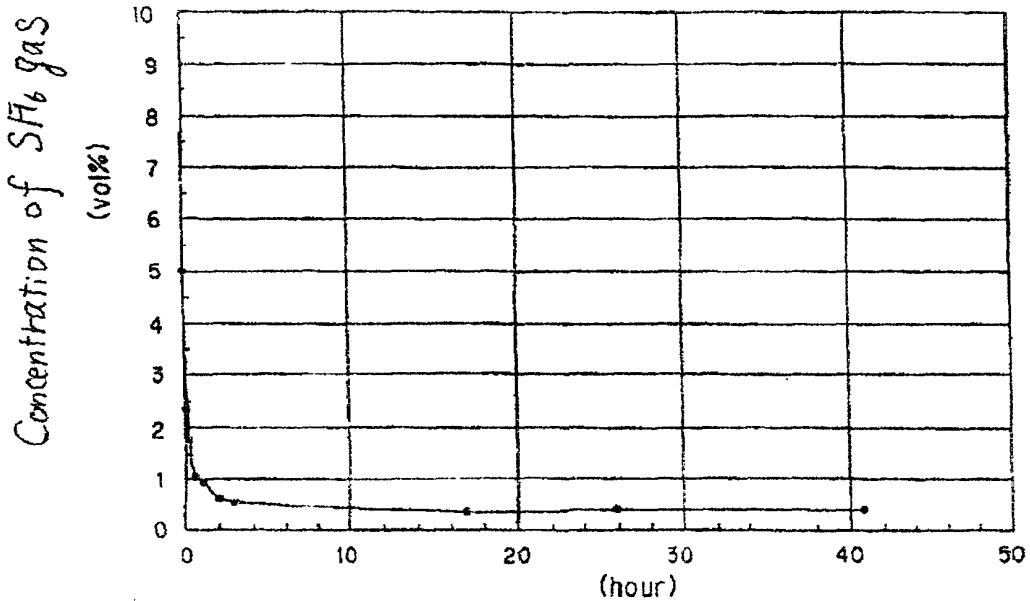
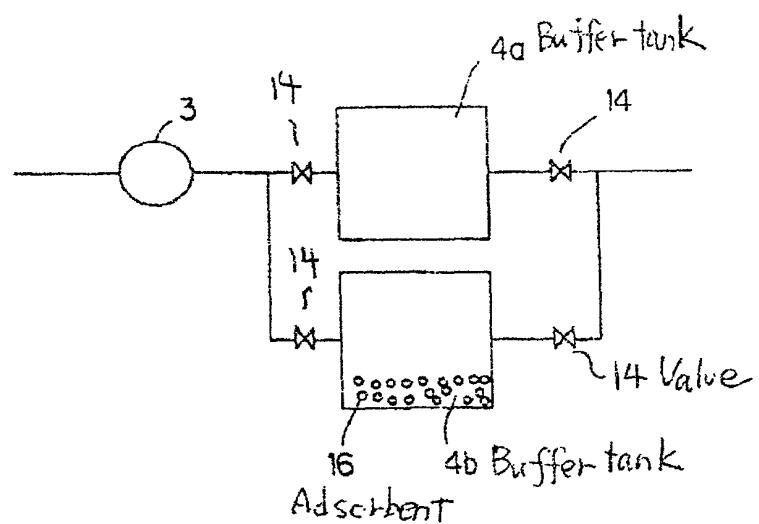
Adsorption Characteristic of  $10\text{\AA}$  Zeolites

Fig. 7



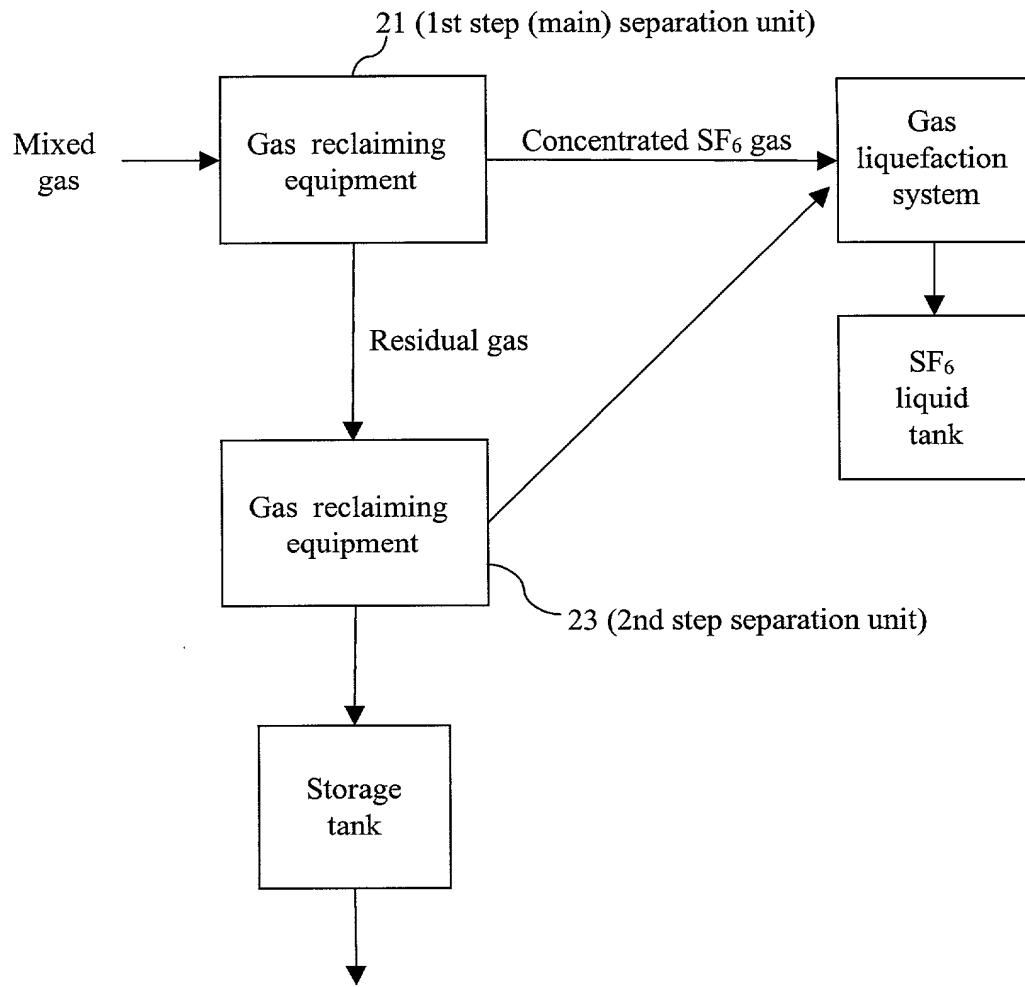


Fig.9

**DECLARATION AND POWER OF ATTORNEY**

As a below named inventor, I HEREBY DECLARE:

THAT my residence, post office address, and citizenship are as stated below next to my name;

THAT I believe I am the original, first, and sole inventor (if only one inventor is named below) or an original, first, and joint inventor (if plural inventors are named below or in an attached Declaration) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**GAS RECLAMING EQUIPMENT**

---

(Attorney Docket No. 016910/0467)

---

the specification of which (check one)

is attached hereto.

      X      

was filed on September 29, 2000 as United States Application Number or PCT International Application Number \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable).

THAT I do not know and do not believe that the same invention was ever known or used by others in the United States of America, or was patented or described in any printed publication in any country, before I (we) invented it;

THAT I do not know and do not believe that the same invention was patented or described in any printed publication in any country, or in public use or on sale in the United States of America, for more than one year prior to the filing date of this United States application;

THAT I do not know and do not believe that the same invention was first patented or made the subject of an inventor's certificate that issued in any country foreign to the United States of America before the filing date of this United States application if the foreign application was filed by me (us), or by my (our) legal representatives or assigns, more than twelve months (six months for design patents) prior to the filing date of this United States application;

THAT I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment specifically referred to above;

THAT I believe that the above-identified specification contains a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the invention, and sets forth the best mode contemplated by me of carrying out the invention; and

THAT I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I HEREBY CLAIM foreign priority benefits under Title 35, United States Code §119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number	Country	Foreign Filing Date	Priority Claimed?	Certified Copy Attached?
11-282045	JAPAN	1 OCTOBER 1999	YES	

I HEREBY CLAIM the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

U.S. Provisional Application Number	Filing Date

I HEREBY CLAIM the benefit under Title 35, United States Code, §120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Application Number	Parent Filing Date	Parent Patent Number

I HEREBY APPOINT the following registered attorneys and agents of the law firm of FOLEY & LARDNER to have full power to prosecute this application and any continuations, divisions, reissues, and reexaminations thereof, to receive the patent, and to transact all business in the United States Patent and Trademark Office connected therewith:

STEPHEN A. BENT	Reg. No. 29,768
DAVID A. BLUMENTHAL	Reg. No. 26,257
BETH A. BURROUS	Reg. No. 35,087
ALAN I. CANTOR	Reg. No. 28,163
WILLIAM T. ELLIS	Reg. No. 26,874
JOHN J. FELDHAUS	Reg. No. 28,822
PATRICIA D. GRANADOS	Reg. No. 33,683

JOHN P. ISACSON	Reg. No. 33,715
MICHAEL D. KAMINSKI	Reg. No. 32,904
LYLE K. KIMMS	Reg. No. 34,079
KENNETH E. KROSIN	Reg. No. 25,735
JOHNNY A. KUMAR	Reg. No. 34,649
GLENN LAW	Reg. No. 34,371
PETER G. MACK	Reg. No. 26,001
BRIAN J. MC NAMARA	Reg. No. 32,789
SYBIL MELOY	Reg. No. 22,749
RICHARD C. PEET	Reg. No. 35,792
GEORGE E. QUILLIN	Reg. No. 32,792
COLIN G. SANDERCOCK	Reg. No. 31,298
BERNHARD D. SAXE	Reg. No. 28,665
CHARLES F. SCHILL	Reg. No. 27,590
RICHARD L. SCHWAAB	Reg. No. 25,479
ARTHUR SCHWARTZ	Reg. No. 22,115
HAROLD C. WEGNER	Reg. No. 25,258

and I request that all correspondence be directed to:

Johnny A. Kumar  
 FOLEY & LARDNER  
 Washington Harbour  
 3000 K Street, N.W., Suite 500  
 Washington, D.C. 20007-5109

Telephone: (202) 672-5489  
 Facsimile: (202) 672-5399

I UNDERSTAND AND AGREE THAT the foregoing attorneys and agents appointed by me to prosecute this application do not personally represent me or my legal interests, but instead represent the interests of the legal owner(s) of the invention described in this application.

I FURTHER DECLARE THAT all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Name of first inventor	Toshikazu SATO
Residence	Tokyo, Japan
Citizenship	Japan
Post Office Address	c/o Intellectual Property Division, Toshiba Corp., 1-1-1, Shibaura, Minato-ku, Tokyo, Japan
Inventor's signature	
Date	

Name of second inventor	Toshiaki INOHARA
Residence	Kanagawa-ken, Japan
Citizenship	Japan
Post Office Address	c/o Intellectual Property Division, Toshiba Corp., 1-1-1, Shibaura, Minato-ku, Tokyo, Japan
Inventor's signature	
Date	
Name of third inventor	Hiroshi MURASE
Residence	Kanagawa-ken, Japan
Citizenship	Japan
Post Office Address	c/o Intellectual Property Division, Toshiba Corp., 1-1-1, Shibaura, Minato-ku, Tokyo, Japan
Inventor's signature	
Date	
Name of fourth inventor	Hiromi NAOTSUKA
Residence	Kanagawa-ken, Japan
Citizenship	Japan
Post Office Address	c/o Intellectual Property Division, Toshiba Corp., 1-1-1, Shibaura, Minato-ku, Tokyo, Japan
Inventor's signature	
Date	
Name of fifth inventor	Takahiro IMAI
Residence	Kanagawa-ken, Japan
Citizenship	Japan
Post Office Address	c/o Intellectual Property Division, Toshiba Corp., 1-1-1, Shibaura, Minato-ku, Tokyo, Japan
Inventor's signature	
Date	